IV.0 Fuel Cells Sub-Program Overview

Introduction

The Fuel Cells activity is focused on supporting research and development activities that address stationary, transportation, auxiliary power unit, and portable power applications, including fuel cell stack components, fuel processors, and balance-of-plant components.

In 2004, significant advances were made in the following key areas: alloy electrocatalysts, high-temperature membranes, fuel cell durability, and turbocompressors. In 2004, projects were awarded for the Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation Project. This five-year evaluation project will collect data to validate performance, reliability, durability and maintenance requirements, and will provide refocused research and development recommendations to the Fuel Cells activity. Additionally, 5 projects were awarded that address critical cost and durability issues for off-road, portable power, and auxiliary power unit (APU) fuel cell systems. The DOE share is $13 million dollars over 3 years with an additional private cost share of approximately $10 million. These selections are in addition to the $75 million over four years announced in July 2003 for 13 firms and educational institutions in twelve states to fund new research in advanced fuel cell technology for vehicles, buildings and other applications.

In June 2004, DOE completed a go/no-go review of on-board fuel processing activities. After examining the progress by fuel processor developers, the report of an independent panel of technical experts, position papers by stakeholders, and other factors including the status of competing technologies, the DOE decided to discontinue development of on-board fuel processing for fuel cell vehicles. Off-board fuel reforming for stationary applications remains a DOE priority, and fuel processor R&D is ongoing in this area.

Technology Status

The key challenges to fuel cell commercialization are component/system cost, performance and durability. Size, weight, and thermal and water management are also key hurdles that are being addressed. To deal with these challenges, the program is organized into the following major areas of activity:

- Transportation Systems - The transportation systems activity includes analyses that address key barriers to fuel cell systems for transportation. Key systems-level barriers include lack of compressors/expanders and sensors that meet automotive packaging and cost requirements, and lack of heat exchangers that can accommodate the low temperature difference generated by fuel cell systems (i.e. balance of plant components). Other activities include studies that appraise the status of critical metrics (such as cost), assess important materials issues such as catalyst usage and recycle, and evaluate water and thermal management strategies. This activity also includes limited development of vehicle APUs for automotive or heavy vehicle applications.
- Distributed Energy Systems - The distributed energy systems activity focuses on overcoming the barriers to stationary fuel cell systems, including cost, durability, heat utilization, start-up time, and managing power transients and load-following requirements. Improved heat usage and recovery are addressed for combined heat and power generation to maximize overall efficiency of (thermal and electrical) systems.
- Fuel Processor R&D - The fuel processor R&D activity includes the development of fuel processors for stationary and auxiliary power applications and the development of fundamental catalysts suitable for a variety of fuel processing applications. Fuel processing technology can be fuel-flexible - capable of processing fuels such as methanol, ethanol, natural gas, propane and diesel into hydrogen.
- Stack Component R&D - The stack component R&D activity focuses on fuel cell stack components whose costs dominate the cost structure and lifetime of the fuel cell system. Critical technical barriers addressed

under this activity include cost, durability, efficiency and overall performance of fuel cell stack components such as the polymer electrolyte membranes, oxygen reduction electrodes, advanced catalysts, bipolar plates, etc.

- Technology Validation (see section V) - The technology validation effort will be an important opportunity to validate component R&D in a systems context under real-world operating conditions and gain experience in the safety of hydrogen-fueled vehicles. By operating vehicles in a controlled manner, all participating parties will be able to quantify the performance and durability, document any problem areas, and provide valuable information to researchers to help refine and direct future R&D activities related to fuel cell vehicles.

Targets, which vary by application, have been established for fuel cell cost, efficiency, durability, power density, specific power, transient response time, start-up time, and emissions, among others. Key performance indicators include cost for transportation fuel cells R&D; electrical efficiency for stationary fuel cells R&D; and durability of fuel cell vehicles under real-world operating conditions for technology validation. For transportation applications, the 2004 cost target has been met. The 2004 cost of a hydrogen-fueled 50-kW fuel cell power system (including on-board hydrogen storage) is $175/kW compared to the 2004 target set at $200/kW. For stationary systems, the 2004 efficiency target has been met: current status is 31% efficiency at full power for a natural gas or propane fueled 50-250 kW stationary fuel cell system vs. a 2004 target of 31% efficiency. The technology validation effort was launched, and projects were awarded in FY 2004 to validate the performance of hydrogen-fueled vehicles and demonstrate durability of 2,000 hours. To date, direct hydrogen fuel cell vehicle durability has been demonstrated on a lab scale and is projected to be 1,000 hours.

FY 2004 Accomplishments

- Demonstrated 1000 hours fuel cell operation with low platinum loading — 0.07 g/kW on the anode side and 0.71 g/kW on the cathode side (2005 total loading goal is 0.6 g/kW) [Los Alamos National Laboratory (LANL) - Brookhaven National Laboratory (BNL)]
- Demonstrated electrolyte polymer with proton conductivity greater than 0.1 Siemens/cm at less than 25% relative humidity at 120°C and greater than 0.06 Siemens/cm at 10°C (Denora)
- Identified membrane degradation mechanism, developed accelerated tests, and tested promising mitigation stratgeies towards automotive durability (DuPont-UTC Fuel Cells-United Technologies Research Center)
- Demonstrated nano-structured thin film cell structure with significantly improved durability compared to platinum-carbon support structures at equivalent performance and platinum cost (3M)
- Developed and tested a turbocompressor/motor controller that meets 2010 FreedomCAR performance, weight, and volume requirements (Honeywell)
- Conducted a fuel cell test on a drive cycle that demonstrated the ability of the fuel cell to consistently follow a transient load (0 - 22 W) over 1200 hours and 3500 cycles (LANL)
- Completed major Go/No-Go decision milestone on on-board vehicle fuel processing with decision to discontinue R&D in this area
- Developed near-net shape manufacturing process for low-cost, carbon/carbon bipolar plate production that meets all electrical, strength and permeability requirements (Porvair, Inc.)
- Argonne National Laboratory (ANL)-led industry/lab fuel processing project made excellent progress toward demonstrating 60 second start-up time

FY 2005 Plans

The Fuel Cell Sub-Program contributes to the President's Hydrogen Fuel Initiative and to the DOE goal for energy security by supporting research, development, and technology validation activities that address stationary, transportation, auxiliary power unit, and portable power applications, including fuel cell stack components, fuel processors, and balance-of-plant components. The President's 2005 Budget Request (subject to Congressional appropriation) addresses the National Research Council's Report recommendations and provides greater emphasis on fuel cell stack components. While industry investment will be focused on engineering development of complete systems, the major focus of the Fuel Cell Technologies program (federal investment) will continue to be high-risk research and development to overcome technical barriers associated with key fuel cell components. These technical barriers include cost, durability, efficiency and overall performance of components such as the polymer electrolyte membranes, oxygen reduction electrodes, advanced catalysts, bipolar plates, etc.

Increased emphasis will be placed on development of advanced membrane technology to increase performance at high temperatures, reduce humidification requirements, improve durability and tolerance to impurities, and lower cost in both stationary and transportation applications. Cost reduction of catalyst-coated membranes will also be an important area of R&D. On-board fuel processing R&D activities that are applicable to stationary reforming will continue. A workshop will be held to assess the R&D needs regarding fuel cell operation at temperatures below freezing, and a small effort will be initiated to address those needs. Increased emphasis will also be placed on understanding the impact of hydrogen purity on fuel cell operation and degradation.